ALTERNATIVE #4 - An In-Basin Solution Using Ground Water Developments

This in-basin alternative is an attempt to meet the projected shortages without importing water and without changing or adding any major surface-water reservoirs (other than ring dikes). It relies instead on groundwater to supplement current surface-water supplies and ring dike reservoirs to capture and store spring runoff. It incorporates eight features:

Feature 4 (modified) — A water-supply pipeline from *a ring dike on the Sheyenne River near Fargo* to the upper Red River near Wahpeton, with a branch to Abercrombie. The pipeline and its associated pumping plant provide water at 18 cfs to offset shortages at the existing Cargill plant and at New Industry 3 near Abercrombie.

Feature 5 (modified) — *Two* 22,000-acre-foot ring-dike reservoirs near Fargo—one on the Red River and one on the Sheyenne. Both require high-capacity, low-head pumping plants to take advantage of short-duration high spring flows—400 cfs for the reservoir on the Red River, but only 200 cfs for the one on the Sheyenne. Some of the water in the ring dikes may be pumped to the Upper Red River (Feature 4), some may be injected for aquifer storage (Feature 9), and some may be released later in the year for use by Fargo, West Fargo, Moorhead, or New Industry 2. No specific sites have been selected for the ring dikes, but they are each assumed to be within 1 mile of the associated river channel.

Feature 7 — A new well field in the Spiritwood Aquifer. This well field would be in northern Barnes County, and estimates suggest that it would yield 6,600 acre-feet per year. The groundwater would be pumped into Lake Ashtabula for re-regulation to meet downstream shortages.

Feature 8 — Purchase of existing groundwater rights. An estimated yield from the Sheyenne Delta, Page/Galesburg, and Elk Valley Aquifers combined would be 8,690 acre-feet, assuming purchase of 33 percent of the existing irrigation wells.

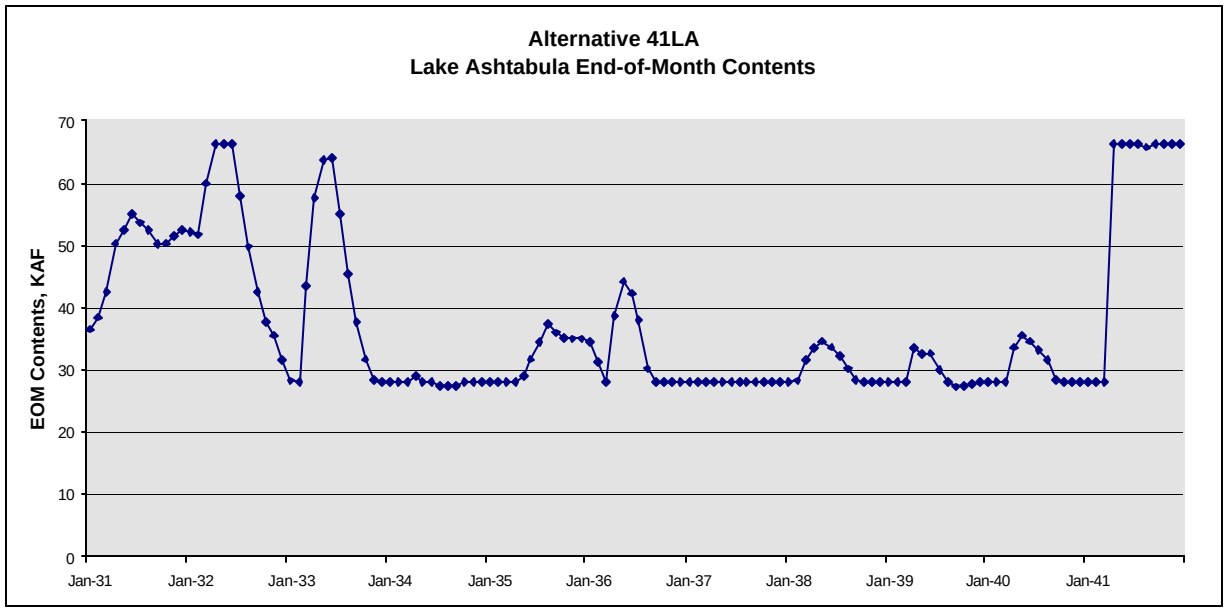
Feature 9 — Aquifer storage and recovery using the West Fargo North Aquifer. This aquifer has approximately 10,000 acre-feet available for recharge and is located under the West Fargo.

Feature 10 — Desalinization of water from Dakota Aquifer. Model run includes an RO desalinization plant near Grand Forks producing 2 MGD. Nine additional plants have been used to make up shortages that remained after the model run.

Feature 12 — Conservation. This is about a 15-percent reduction in demand. However, it is offset by a 15- to 20-percent increase in demand during drought years.

After establishing the components of this alternative, the model runs show that it does *not* meet all of the projected 2050 Reclamation demands without extensive use of Dakota Aquifer water and desalinization water treatment plants. Shortages remaining after the initial model runs are due to the limited ground water supplies available. Aquifers used for municipal supply have been modeled as a steady ground water withdraw rate where the annual withdraw volume is the yield estimated from the

new well field in the Spiritwood and Dakota Aquifers and water rights transfers from the Elk Valley, Sheyenne Delta, and Page/Galesburg aquifers. The 28,000 ac-ft Lake Ashtabula minimum pool has been maintained in the model run. Lake Ashtabula end-of-month contents during the critical drought sequence are shown in the following graph.



Feature 4 Summary: Water Supply Pipeline to the Upper Red River

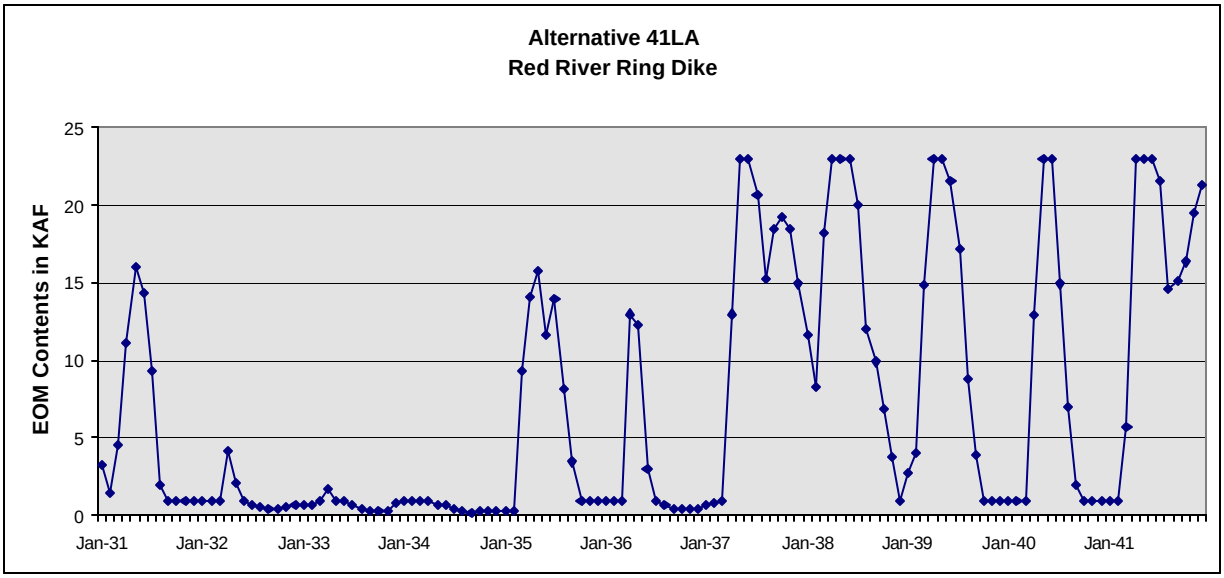
This feature has been modified slightly by placing the pumping plant and water supply for the Upper Red River shortages on the ring dike reservoir on the Sheyenne River. Therefore, the length of pipeline needed to reach Abercrombie and Wahpeton is slightly longer. Cost comparison of this supply vs additional desalinization of Dakota Aquifer water that could be supplied to New Industry 3 near Abercrombie and the existing Cargill plant near Wahpeton show this pipeline supply to be less expensive. The trade off of using the desalinization plant option is that it provides a treated water supply whereas the ring dike and pipeline supply provide only raw water to the users. This pipeline supply is designed for a maximum 18 cfs capacity.

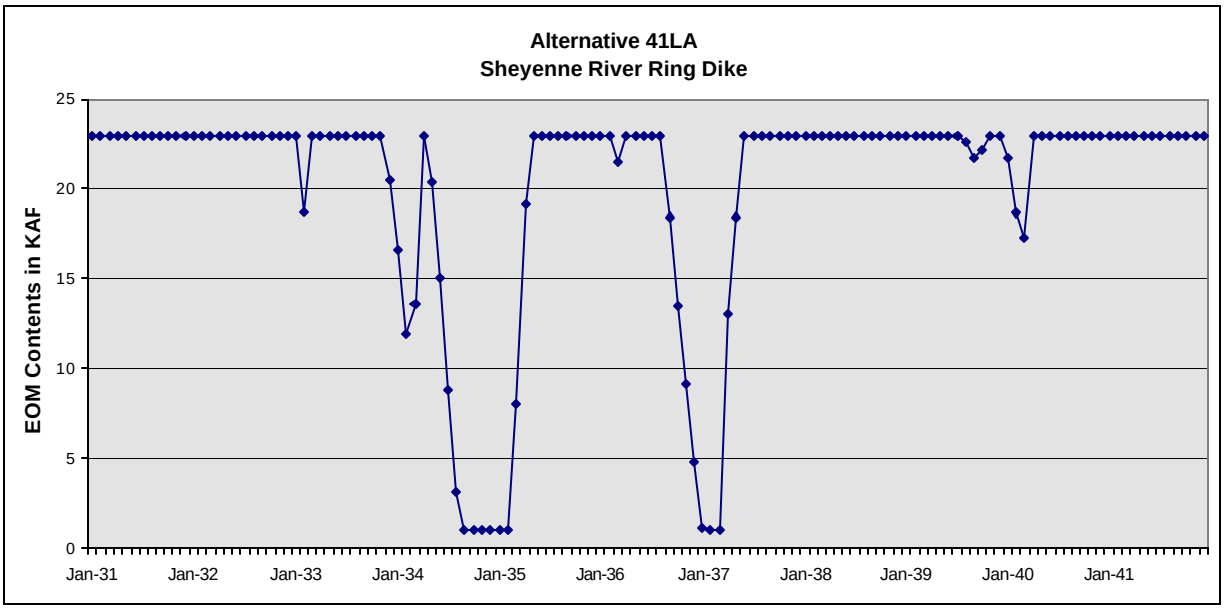
Feature 5 Summary: Ring Dike Reservoirs on the Red and Sheyenne Rivers

Two ring dike reservoirs are included in this alternative in order to enhance surface water supplies. The ring dike on the Red River is assumed to be located near the city of Fargo. The historic 1930's high spring flows on the Red River allow the use of a 400 cfs diversion pumping plant to capture the short duration, high spring flows. The historic 1930's high spring flows on the Sheyenne River are not as great as on the Red River, therefore only a 200 cfs diversion pumping plant is required. The Sheyenne River ring dike can provide some flexibility of storage with releases from Lake Ashtabula that could be stored again, so the size of this ring dike is maintained at the maximum estimate of 22,000 acre-feet. The Sheyenne River ring dike is also used as the supply source for the upper Red River supply pipeline.

The ring dike end of month contents are illustrated in the following graphs

The Red River ring dike is used as a supplemental municipal supply and as the water supply for the aquifer storage and recovery system. It is assumed that water to be recharged into the West Fargo North Aquifer will be withdrawn from this ring dike and be treated by the existing Fargo Treatment Plant during times of lower city demand.





Feature 7 Summary: New Ground Water Supply Development

Due to the existing level of use of the aquifers in the study area, only the Spiritwood Aquifer has been

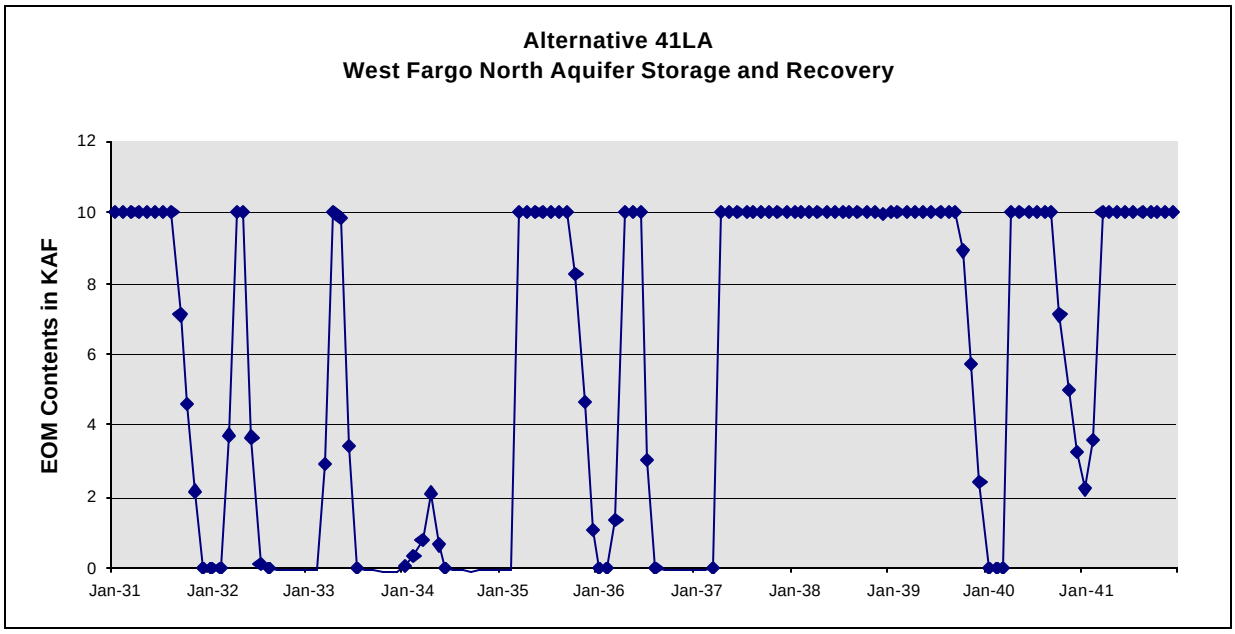
considered as a significant source of ground water for new well development. A new well field in the Spiritwood Aquifer has been estimated (see Feature 7 writeup for details). This well field would be in northern Barnes County, and estimates are that it would yield 6,600 acre-feet per year. The groundwater would be pumped as a steady supply into Lake Ashtabula for re-regulation and release to meet downstream shortages. Costs estimated are for the installation of the well field and the operation required to deliver ground water to Lake Ashtabula.

Feature 8 Summary purchase of existing groundwater rights.

An estimated yield from the Sheyenne Delta, Page/Galesburg, and Elk Valley Aquifers combined, would be 8,690 acre-feet, assuming purchase of 33 percent of the existing irrigation wells. The details of this feature are provided in the writeup of Feature 8. The cost estimate used for this feature includes purchase of the irrigated land, installation of new extraction wells and appropriately sized pumps, and a pipeline transport to the city boundary (Elk Valley and Page/Galesburg aquifers) or to the Sheyenne River (Sheyenne Delta aquifer). This feature is assumed to provide an additional raw water supply, modeled as pumped at a steady rate.

Feature 9 Summary: Aquifer Storage and Recovery

The use of aquifer storage and recovery on the West Fargo North Aquifer is limited to approximately 10,000 acre-feet of unsaturated aquifer space (see Feature 9 writeup). The source of water for the aquifer storage and recovery system has been estimated to be Red River high spring flows that are stored in a surface storage ring dike feature. Water stored in the ring dike will require treatment prior to injection. Injection and recovery is dependent upon the aquifer characteristics and for this initial estimate, the assumption was that injection could be sustained over 9 months of the year (low demand times) and withdraw would take place over 3 months of the year (high demand times). Additional treatment plants are not included in this estimate. Capacity from existing municipal treatment plants, during times of low demand, has been assumed to be used as the treatment method for the injection water.



Feature 10 Summary: Desalinization of water from Dakota Aquifer.

The remaining shortages of this model run are proposed to be met by additional development of the Dakota Aquifer. The Dakota Aquifer is fairly widespread, however the water quality is poor. To make a complete study area water supply, Dakota Aquifer use along with desalinization plants (RO Treatment Plants) are included in the alternative estimate. Exact locations of Dakota Aquifer wells have not been made, however, it is assumed that wells could be located at or near the shortage sites. Some significant exploration costs may be involved to obtain satisfactory yields. These shortages are significant in overall size, and are summarized individually in the following cost estimate table.

These appraisal level cost estimates for a water treatment plant that would desalt the Dakota Aquifer water are based on water quality obtained from Table 2 (p.11-12) and Table 3 (pp.15) of the unpublished report titled "Evaluation of the Natural Freeze-Thaw Process for the Desalination of Groundwater from the Dakota Aquifer to Provide Water for Grand Forks North Dakota" by John E. Boysen and John A. Harju et al. Various flow rates were used based on the remaining maximum month shortages. Both capital and operation and maintenance (O&M) costs are provided for each of the flow rates.

The overall process design will include cost estimates for the treatment of ground water using reverse osmosis (RO), building construction costs and brine disposal evaporation ponds. The overall objective was to reduce the total dissolved solids (TDS) from 5040 mg/L to 500 mg/L and 300 mg/L. Deviation from the parameters listed in Table 1 by more than 10% will make the capital and operation and maintenance costs inaccurate and will require new model generation and resulting cost estimates.

The following table indicates both capital costs and O&M costs associated with construction and operation of a desalination plant. Included in the capital cost estimates are 5% for mobilization, 20% unlisted items, 25% contingencies, and 33% for investigations, mitigation, engineering and construction management. O&M estimates include 20% unlisted items and are based on continual operation of the system. Intermittent operation will increase O&M costs by requiring more frequent membrane cleaning, storage, and replacement.

Table 4.1A
Red River Cost Estimate for Product Water of 300 mg/L TDS

Location	RO Plant Flowrate (MGD)	Treatment Plant Capital Cost ($)	Brine Rate (MGD)	Brine Pond Capital Cost ($)	O&M Cost ($/yr)
Fargo & West Fargo	27.5	$36,074,050	4.85	$223,000,000	$5,005,448
Valley City	1.2	$ 2,463,436	0.21	$12,600,000	$ 339,685
New Industry #5	5.2	$ 8,145,756	0.92	$44,600,000	$1,059,467
Agassiz, TriCounty, Walsh Rural Water	0.8	$ 2,039,344	0.14	$9,400,000	$ 289,853
Cass Rural Water	2.6	$ 4,763,321	0.46	$23,800,000	$ 625,272
Dakota Water Users	1.0	$ 2,254,272	0.18	$11,000,000	$ 314,705
Grand Forks Traill & Traill Water Users	2.9	$ 5,088,141	0.51	$26,200,000	$ 665,512
Langdon Rural Water	0.35	$ 1,535,085	0.06	$5,800,000	$ 148,121
Southeast & Ransom-Sargent Rural Water	1.2	$ 2,463,436	0.21	$12,600,000	$ 339,685
TOTAL COSTS		$ 64,827,000		$369,000,000	$ 8,788,000

Brine produced by treatment of the ground water using reverse osmosis will be disposed of in two bermed evaporation ponds. Each pond will be capable of handling the entire volume of brine produced annually while the second pond can be used during servicing or as a backup to the first pond. The ponds will be constructed with a slope ratio of 3:1 and contain a geomembrane liner resistant to ultra violet light if exposed. The surface area required is based on an evaporation rate of 12 inches per year. The depth of the pond will be 8 feet in which 5 feet will be used for any excess water while maintaining a freeboard of 3 feet. The ponds will be constructed with minimal excavation in an effort to "balance" cut and fill. A minimum width of 12 feet between the two ponds will be included for access. The costs provided in Table 3 include the purchase of land, construction of two evaporation ponds (excavation),

construction of embankment, geomembrane liner, geomembrane liner backing, 7 foot high chain link fence surrounding both ponds, stockpiling of excess material, 5% mobilization, 20% unlisted items, 25% contract cost (contingencies), and 33% field cost (investigation, mitigation, engineering and construction management). These costs provided in Table 3 were determined from a straight line extrapolation from construction costs associated with RO brine disposal for a 1 MGD and 2 MGD treatment plant.

Operation and maintenance costs associated with these ponds are not included in this estimate. The evaporation ponds will accumulate solids (salts) over time and will be required to be removed by either a vacuum truck (if dried) or pumped (if in a thick brine). The solids will then be disposed of in a certified domestic landfill. The frequency is difficult to determine since environmental conditions are difficult to predict. Once the liner is installed, tracked vehicles are not allowed on top of the liner.

ESTIMATE WORKSHEET

ALTERNATIVE #4
GROUND WATER SUPPLIES

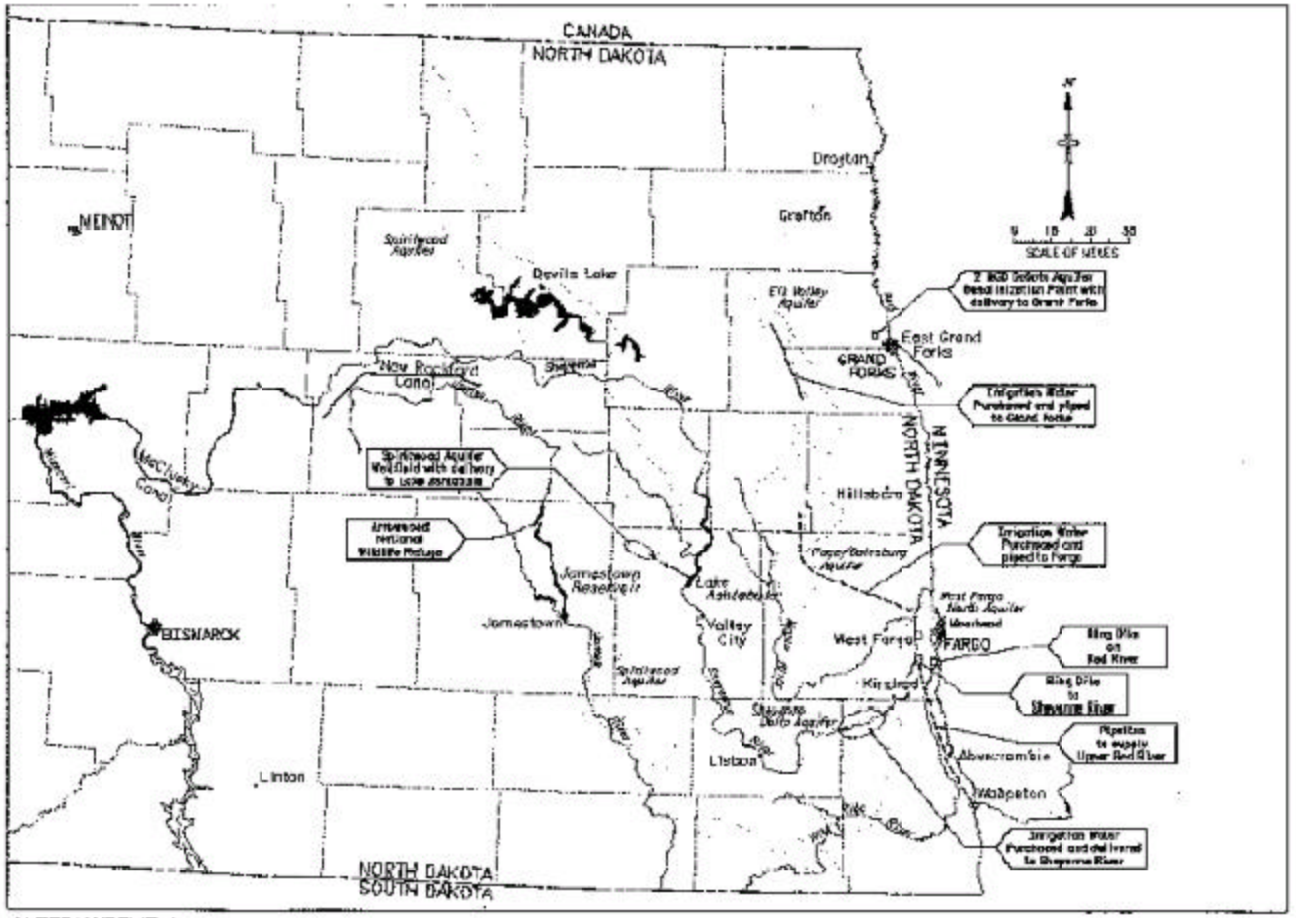
PROJECT: Red River Valley Water Supply

DIVISION:

FILE:ALT_COST.WK4

DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT	LIFE	Annual Operation	Annual Maintenance	Annual Replacement	Annual Energy	TOTAL ANNUAL
Feature 4F											
Pumping Plant and Pipeline to upper Red River		18	cfs	LS	$69,000,000		$48,000	$12,800	$238,900	$71,300	$371,000
											$0
Feature 5											$0
Red River Ring Dike		22,000	Ac-Ft	LS	$26,490,000		$1,000		$8,600		$9,600
Ring dike Pumping Plant		400	cfs	LS	$28,000,000		$30,000	$25,000	$2,200	$118,000	$175,200
ROW and Relocations				LS	$2,320,000						$0
Sheyenne River Ring Dike		22,000	Ac-Ft	LS	$26,490,000		$1,000		$8,600		$9,600
Ring dike Pumping Plant		200	cfs	LS	$16,500,000		$30,000	$20,000	$1,400	$70,000	$121,400
ROW and Relocations					$2,320,000						$0
											$0
Feature 7											$0
Spiritwood Aquifer Wellfield		15	wells	LS	$25,000,000		$79,300	$31,700	$206,500	$125,600	$443,100
Land & ROW		150	acres	LS	$150,000						$0
Feature 8											$0
Page/Galesburg Aquifer Wellfield		8	wells	LS	$29,000,000		$25,000	$15,000	$70,200	$54,300	$164,500
Page/Galesburg Irrigation Water Purchase		5922	acres	LS	$5,922,000						$0
Elk Valley Aquifer Wellfield		16	wells	LS	$25,000,000		$40,000	$30,000	$67,800	$29,400	$167,200
Elk Valley Irrigation Water Purchase		5542	acres	LS	$5,542,000						$0
Sheyenne Delta Aquifer Wellfield		7	wells		$5,500,000		$25,000	$15,000	$45,700	$40,500	$126,200
Sheyenne Delta Irrigation Water Purchase		3257	acres		$3,257,000						$0
											$0
Feature 9											$0
WFN Aquifer Recharge and Recovery		18	wells		$12,500,000		$80,500	$40,200	$164,900	$40,100	$325,700
											$0
Feature 10											$0
Desalinization of Dakota Aquifer Water		43	MGD		$442,430,000		$8,787,750				$8,787,750
Estimate is for 9 Plant Sites and Dakota Aquifer Wells											
(Includes Rural Water Shortages& New Industry5)											
Desalinization Plant at Grand Forks		2	MGD		$40,400,000		$480,000				$480,000
						Subtotal	$9,627,550	$189,700	$814,800	$549,200	$11,181,250
										Unlisted Items'+/- 20%	$2,238,750
Existing GDU Supply Works, Continuing O&M										GDU Assigned Cost	$2,139,000
Mobilization (+/- 5%)					Included Above				**TOTAL ANNUAL OM&R**		**$15,560,000**
SUBTOTAL					$765,821,000						
Unlisted Items (+/- 20%)					Included Above						
CONTRACT COST					$765,821,000				**ANNUALIZED CAPITAL COST**		**$54,610,000**
Contingencies (+/- 25%)					Included Above						
FIELD COST					$765,821,000						
USBR Invest., Mitig., Engr. & Constr. Mgt. (+/- 33%)					Included Above				**TOTAL ANNUALIZED COST**		**$70,170,000**
TOTAL ESTIMATE					**$765,800,000**						

QUANTITIES		PRICES	
BY Rburnett		**BY** K. Copeland	**CHECKED**
DATE	**APPROVED**	**DATE**	**PRICE LEVEL** Appraisal



ALTERNATIVE 4